Energy Efficient Pulping/Slushing in Paper Manufacture

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

GOOD PRACTICE GUIDE 163

ENERGY EFFICIENT PULPING/SLUSHING IN PAPER MANUFACTURE

This booklet is No. 163 in the Good Practice Guide Series. This Guide is aimed at paper-makers and shows the various types of energy efficient pulping/slushing solutions that can be implemented. Considerations governing the use of pulpers for different furnishes are described; for virgin pulp, dry broke, old corrugated containers, newsprint and pamphlets, and UMT pulping.

Prepared for the Department of the Environment by:

ETSU
Harwell
Didcot
Oxfordshire
OX11 0QJ

and

G H Nuttall
The Fold
Kirkby Overblow
North Yorkshire
HG1 3HQ

First published October 1995, Reprinted March 2001.

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Energy Efficiency Enquiries Bureau
ETSU
Harwell
Didcot
Oxfordshire
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FOREWORD

This guide is part of a series produced by the Department of the Environment under the Best Practice programme. The aim of the programme is to advance and spread good practice in energy efficiency by providing independent, authoritative advice and information on good energy efficiency practices. Best Practice is a collaborative programme targeted towards energy users and decision makers in industry, the commercial and public sectors, and building sectors including housing. It comprises four inter-related elements identified by colour-coded strips for easy reference:

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If you would like any further information on this document, or on the Best Practice programme, please get in touch with your Regional Energy Efficiency Office. Their addresses are given below:

ENGLAND

Energy Efficiency Office
(East Midlands Region)
Cranbrook House
Cranbrook Street
Nottingham
NG1 1EY
Tel: 01159 352292

Energy Efficiency Office
(North East Region)
Government Office for the North East
Wellbar House
Gallowgate
Newcastle-upon-Tyne
NE1 4TD
Tel: 0191 201 3343

Energy Efficiency Office
(North West Region)
Government Office- North West
Sunley Tower
Piccadilly Plaza
Manchester
M1 4BA
Tel: 0161 952 4282

Energy Efficiency Office
(South East Region)
Charles House
Room 554
375 Kensington High Street
London
W14 8QH
Tel: 0171 605 9160

Energy Efficiency Office
(Eastern Region)
Heron House
49-53 Goldington Road
Bedford
MK40 3LL
Tel: 01234 276194

Energy Efficiency Office
(South West)
Government Office for the South West
Tollgate House
Houlton Street
Bristol BS2 9DJ
Tel: 01179 878665

Energy Efficiency Office
(West Midlands Region)
Room 603
Five Ways Tower
Frederick Road
Birmingham
B15 1SJ
Tel: 0121 626 2222

Energy Efficiency Office
(Yorkshire/ Humberside Region)
Government Office for Yorks & Humberside
City House
New Station Street
Leeds
LS1 4JD
Tel: 0113 283 6376

Energy Efficiency Office
(NORTHERN IRELAND)
Dept of Economic Development
Netherleigh
Massey Avenue
Belfast
BT4 2JP
Tel: 01232 529358

Energy Efficiency Office
(SCOTLAND)
Scottish Office Industry Dept
Energy Division R6/47
New St Andrew's House
Edinburgh
EH1 3TG
Tel: 0131 244 4665

Energy Efficiency Office
(WALES)
Welsh Office
Industry & Training Department
Cathays Park
Cardiff
CF1 3NQ
Tel: 01222 823126

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ENERGY EFFICIENT PULPING/SLUSHING IN PAPER MANUFACTURE

1. INTRODUCTION

In the manufacture of paper in the UK three parts of the process account for approximately half the total consumption of electricity. These are refining, vacuum pumps and the pulping/ slushing of papermaking stock. Good Practice Guides have already been published by the Energy Efficiency Office covering the first two of these. This Guide deals with the third.

The use of pulpers to disintegrate virgin pulp, recycled waste and broke is common to all papermaking, and machines may have as many as five individual pulpers involved in the process. A 1989 survey of mills (mainly non-integrated in the UK) provided information on the pulping of raw material and broke (both dry and from under the machine), and revealed that pulping accounted for between 30 and 150 kWh/te of electricity used, or between 10% and 25% of total usage on a machine, depending on the grades being manufactured.

It was estimated that this amounted to a UK consumption of some 300 million kWh, and as much as half of this may be saved by using modern techniques: a massive saving in resources and a substantial potential boost to mill profitability.

This Good Practice Guide outlines some of the considerations involved in the pulping of papermaking stock, and suggests areas where improvements in energy efficiency could be made.

As part of the preparation of this Guide, a number of manufacturers of pulpers were asked to supply figures on expected energy use for particular pulping duties, and the range of these figures is quoted in tables throughout the text. The Guide also contains a number of specific practical case histories of improvements undertaken in particular mills.

This Guide is divided into the following Sections:

- Section 1 introduces the Guide and discusses basic and operational considerations;
- Section 2 considers factors affecting energy use, including consistency, temperature, and tub shape;
- Sections 3 to 7 describe the considerations governing the use of pulpers for different furnishes. The types of application considered are virgin pulp, dry broke, old corrugated containers (OCC), newsprint and pamphlets, and under-the-motor (UTM) pulping;
- Section 8 discusses pulper drives;
- Section 9 describes the maintenance considerations;
- Section 10 provides a maintenance & operational checklist;
- Appendix A lists the pulper manufacturers that assisted in the preparation of this Guide.

It should be noted that there is no intention to comment adversely on particular manufacturers whose equipment may have been replaced. In general all manufacturers have improved the energy efficiency of their newer designs, and the poor efficiency of the installations they replaced has often arisen from changes in pulping furnish and throughput. Similarly, the case histories or other references to specific designs or manufacturers are not intended to indicate that the replacement equipment is the only or the best solution to particular problems. The intention of the Guide is to show the papermaker the types of solutions that can be implemented, so that he can then approach a number of manufacturers of pulping equipment to determine which is the most appropriate for his needs.

1.1 Basic Considerations

Certain terms in common use in the papermaking industry must first be clarified.

The disintegration in water of the cellulose raw material furnish, whether in the form of virgin pulp, recycled waste or broke, is variously referred to as 'repulping', 'slushing' or 'pulping'. The first term is the correct one, since all of the fibre which is disintegrated in a paper mill has previously been prepared in a 'pulping' process, be it chemical, mechanical or a combination of the two. 'Slushing' is equally sound as a description of what happens. However, in the UK the process is universally known as *pulping*, whether it is raw material in the form of bales of virgin pulp, loose or bales of waste, or broke in slab, reel or wet form. The term *pulping* is therefore used throughout this Guide. The usual term for pulping equipment, *'pulper'*, will also be used. A typical pulper is shown in Fig 1. Several other designs exist - please contact manufacturers for more detailed information.

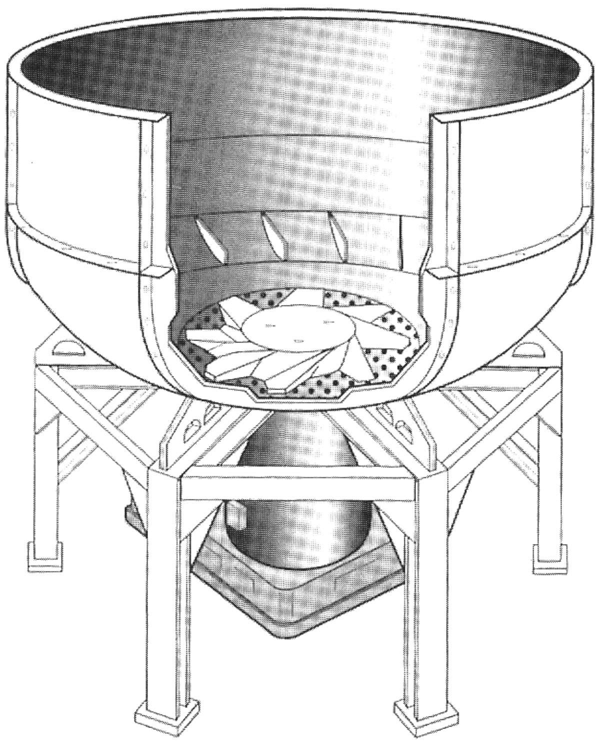

Fig 1 Typical pulper design

The action of pulping reduces the furnish to individual fibres and fibre bundles. The rotor induces a combination of mechanical and hydraulic forces in the pulper tub. In vertical pulpers, superimposed on the rotational flow is a movement outwards from the rotor, up the sides of the tub and back towards the centre of the vortex. Baffles on the tub wall and other modifications, such as the D-chord baffle provided by Black Clawson or the Double Sigma design from Beloit, seek to break up the tendency for rotational flow to become mainly laminar. If the flow should become laminar, it considerably reduces the pulper's effectiveness, and wastes energy by building up useless rotational momentum and generating a severe vortex.

Initially, the main action reducing the furnish is a mechanical one as the sheets are torn into small pieces by the rotor. Rapidly this action is superseded by *defibring*, reducing the pieces to individual fibres and fibre bundles. This results from a combination of shear forces induced by the hydraulic movement, and attrition caused by the severe mechanical forces acting on fibres forced hydraulically into the very fine gap (adjustable to roughly 2 mm) between the rotor and the *bedplate*.

The bedplate, sometimes referred to as the *extraction plate*, is perforated to admit fibrous material to the dump pump and may also have cutting bars in the design. It is situated underneath and/or around the tub. If the rotor blades cover the entire extraction plate, all fibres are treated long before being discharged.

The size of holes in a bedplate differs between manufacturers. Some support a larger size for batch pulping in order to reduce the time needed to empty the pulper; others use larger holes in continuous pulping to reduce the possibility of the pulper clogging up. Generally hole size is between 3 mm and 25 mm, depending on duty, and the holes may be conically drilled, opening outwards, since this is believed to assist in keeping them clear.

Many manufacturers have trial facilities to treat the customer's furnish when the optimum hole size can be assessed. Appropriate hole size is also dependent on the processing facilities following, or allied to, the pulper.

1.2 Operational Considerations

The key elements which determine the energy consumed to reduce the furnish are:

- the design of the rotor;

- the positioning of baffles and vanes on the base of the tub;

- the configuration of the bedplate behind the rotor.

As shown in Tables 1-5 the difference in energy consumption to achieve a specific result may differ considerably from one manufacturer to another.

Improvements in design, leading to 25% or more reduction in energy use for the same application, are periodically claimed by manufacturers. The appropriate modifications frequently have an attractive payback, especially when associated with increased throughput. Another factor affecting performance of different pulper designs is the relationship between power and tub volume; increased power to volume ratio is claimed to reduce specific energy consumption. Rotor designs can vary enormously, depending on the use to which they are to be put and on the individual manufacturer. Examples of some designs are shown in Fig 2.

Pulping is carried out either in a batch or continuous process. Batch pulping requires the pulper to be charged with a weighed amount of material and a fixed volume of water (returned white or backwater) to maintain a uniform consistency from batch to batch. In continuous pulping fibre and water are added continuously, with tub level and consistency separately controlled.

As a general rule the following methods are used:

- pulpers charged with virgin pulp are commonly run batchwise though there is now a trend to the use of continuous pulping;

- for recycled material which has to be de-inked, pulping is normally batchwise;

- broke pulpers are operated both batchwise and continuously, depending on situation and specific use;

- brown waste is pulped continuously except in the case of some specialised products.

Continuous pulping is, however, an option for any single product stock preparation system.

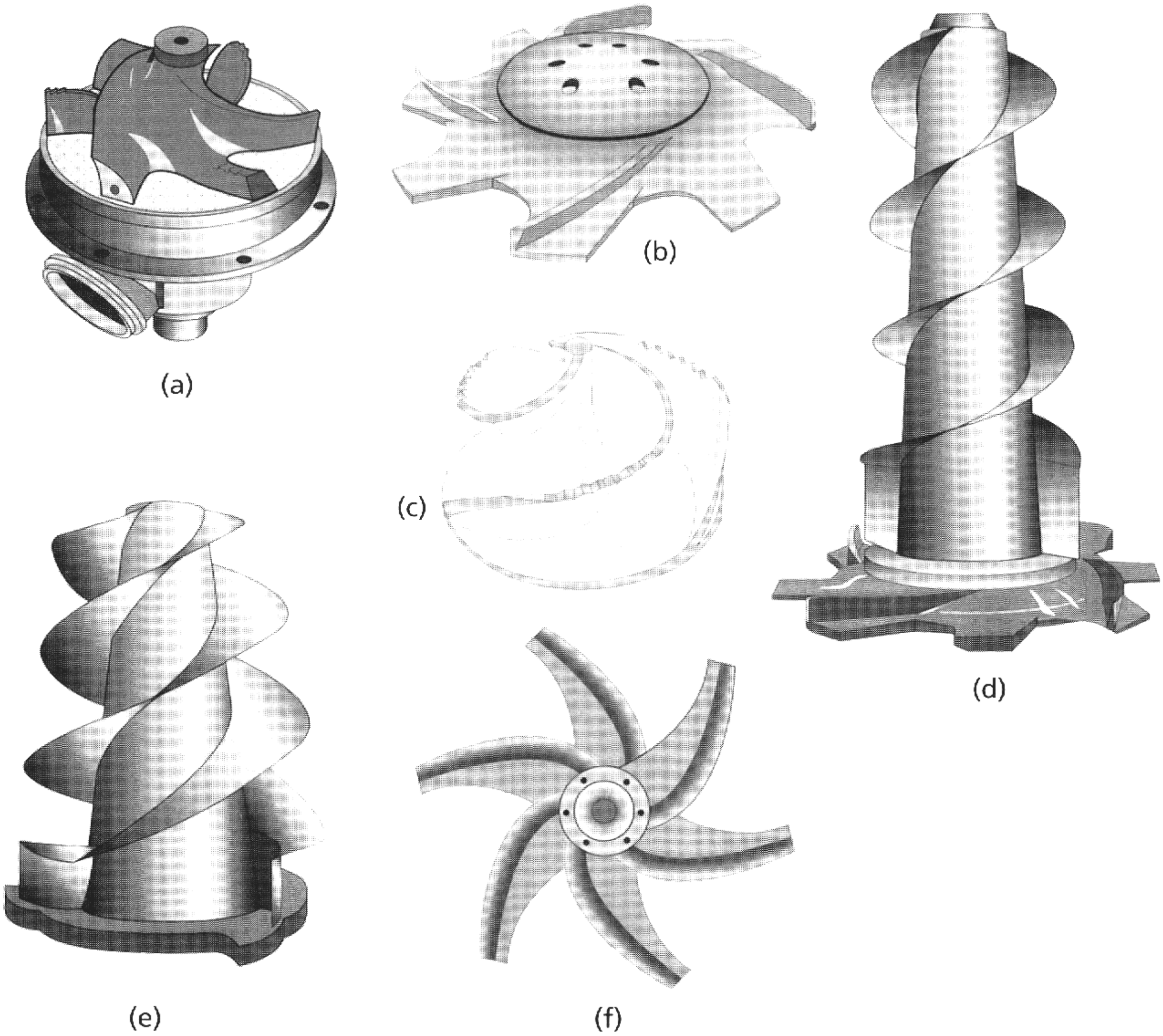

Fig 2 Examples of some different rotor designs

Although rarely the major consideration in choice, continuous pulping will generally use less power than batch to achieve a given level of defibring, since no power is wasted during emptying and filling. In batch pulping the rotor may be stopped or slowed down during the cycle to react to changes in demand downstream.

2. FACTORS AFFECTING ENERGY USE

2.1 Effect of Consistency

Pulping was traditionally carried out at 4% to 6% consistency. *Medium consistency* pulping, up to 10% or so consistency, was introduced some years ago by adapting the rotor design, usually enlarging the diameter and adding helical flights extending high up the pulper tub forcing a downward and inward motion. An example of this type of rotor is illustrated in Fig 2 (d). An alternative that achieves the same increase in consistency is the Sulzer Papertec Bi-pulper, illustrated in Fig 3, which employs a separate helical rotor hanging from a beam above the basic rotor, as yet there are no applications of this in the UK

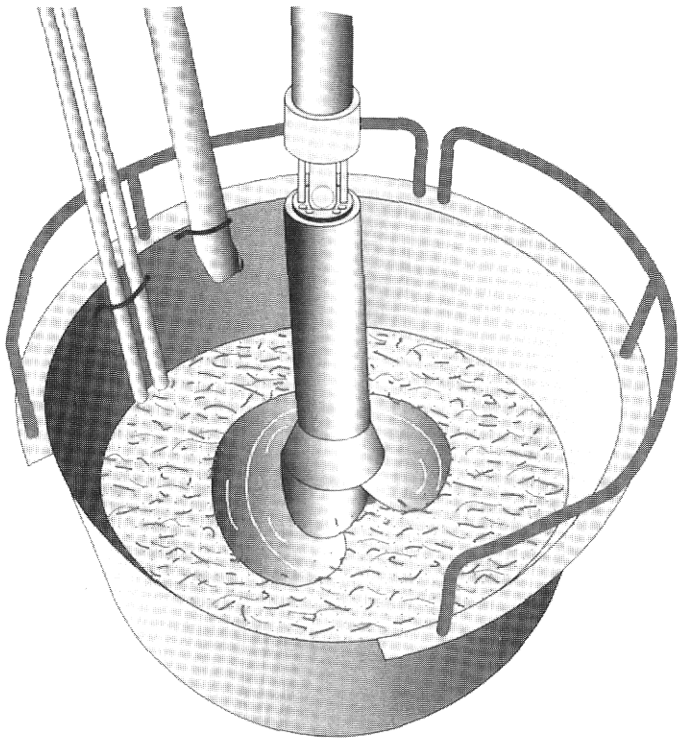

Fig 3 Sulzer Papertec Bi-Pulper

Rotors for medium consistency operation were later further modified to allow pulping at *high consistencies* up to as much as 18%. The mainly shear action of these pulpers, and their slower rate of rotation (of necessity as cavitation and fibre burning occurs more easily in the more viscous higher consistency stock), are particularly beneficial for loosening ink particles with furnishes requiring de-inking. It is also considered that pulping at high consistency, which is always batchwise, does not reduce the fibre length so much, a useful characteristic when the furnish is predominantly recycled.

The effect of consistency on energy consumed in pulping is not straightforward. An example is shown in Fig 4, and is the result of pilot plant trials pulping pine at different consistencies and power inputs. For this particular design the effectiveness of pulping over a given length of time, as measured by development of defibring as a percentage of complete fibre separation, has a clear optimum point at around 6.5%.

However, work has also been reported by Savolainen of Tampella (now Valmet) showing a reduction of about 30% in specific energy consumption (to reach a degree of defibring as measured by retention on a Sommerville screen plate) going from 3.5% to 7% consistency, and by over 50% going up to 10% consistency. A colleague of his, Merrett, earlier reported a reduction to a third in specific energy consumption by raising consistency from 4.8% to as high as 12.7%. These results contradict those of Sunds Defibrator unless the conditions were such that an optimum consistency was not reached.

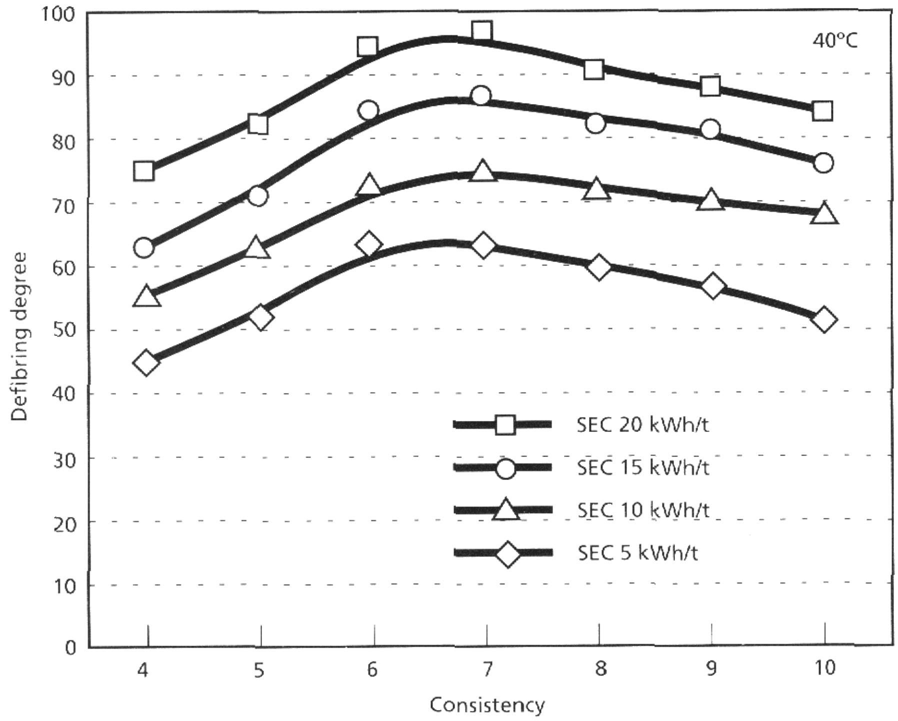

Fig 4 Variation in degree of defibring with consistency (provided by Sunds Defibrator

While it is reasonable to expect that a particular model of pulper may have an optimum consistency of operation, there is ample evidence that, up to a point, higher consistencies in a pulper brought about by a change in design of the rotor can be beneficial for reducing specific energy consumption. An example of where this has been done is given in Case History 3.

Running at a higher consistency for a particular duty does not in itself necessarily reduce specific energy consumption. This may be demonstrated by comparing the expected specific energy use of equipment to treat a specified throughput of furnish, as quoted by different manufacturers. Those operating at high consistency frequently use more energy.

This applies most noticeably to the pulping of recycled fibre which needs de-inking. In this case (see Section 6), the specific energy used by pulpers from different manufacturers does not bear any clear relationship to consistency. There are also other considerations which affect the economy of operation. Higher consistency reduces the amount of de-inking chemicals and steam heating for the stock, both of which are essential to loosen the ink. When this is taken into account the balance is a complex one which has to be assessed for each application.

2.2 Other Factors Affecting Energy Use

Apart from consistency, the main factor which affects the energy consumed in pulping is *temperature*. As temperature is increased the reduced viscosity of the fibre suspension and of fibre bonding leads to a lower energy demand to achieve defibring. All manufacturers agree on this point and one example is produced from Valmet (see Fig 5). This illustrates the effect of temperature at different consistencies on the degree of disintegration (as measured by retention on a 0.15 mm Sommerville screen plate) of old corrugated containers (OCC). The increase from 20°C to 40°C is particularly marked, and indicates clearly the benefit, from an energy standpoint, of at least warming the stock. Savolainen, from the same company, reported on experimental work examining the achievement at a given degree of defibring. He has claimed this showed that specific energy consumption of OCC will drop at least 50% by raising temperature from 20°C to 60°C.

Effect of Temperature to Pulping Degree after 10 min OCC

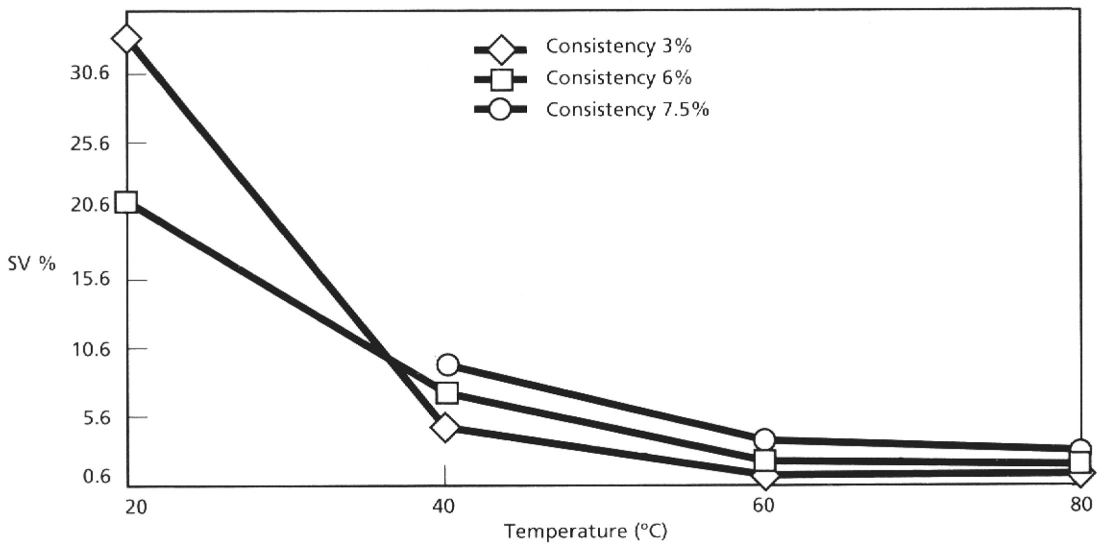

Fig 5 Variation in degree of defibring with temperature (provided by Tampella)

Black Clawson state that in continuous pulping raising the temperature from 20°C to 60°C steadily increases throughput, and can reduce by a quarter the specific energy consumed.

The temperature of pulping will normally be dictated by other requirements of the process, in particular by the temperature of the backwater. Where this is heated to enhance drainage the whole system will assume a higher temperature dependent on the degree of closure. Where heat is applied in the pulper it will usually be because of a specific need, for example in de-inking or pulping of wet-strengthened paper, and rarely with energy saving in mind. If steam is used to heat stock in a pulper a heat exchanger is preferable, both to allow softened condensate to be returned, and to stop the burping that can occur at high consistency.

Another factor affecting energy use in pulping is the pH, especially for furnish that is difficult to defibre, it is generally considered that the higher the pH, the better.

The use of enzymes may also become effective for reducing energy consumption in the future.

2.3 Tub Shape

The earliest modification to the conventional round tub was devised by Black Clawson, a simple but highly effective 'D-Chord' baffle which has a significant impact on output and energy consumption. This arrangement is now available for all furnishes, and is illustrated in Fig 6. Removing a segment of the usual cylindrical shape has the effect of turning the flow in towards the centre opposite the chord, thereby offsetting the axis of the central vortex. This in turn improves bale submergence and disintegration, by increasing turbulence in the tub and by better use of the rotational momentum.

Black Clawson claim that retro-fit of the D-chord can increase productivity by up to 40% and allow use of higher consistencies, with paybacks of under one year. Case history 4 (see page 20) provides an example of this.

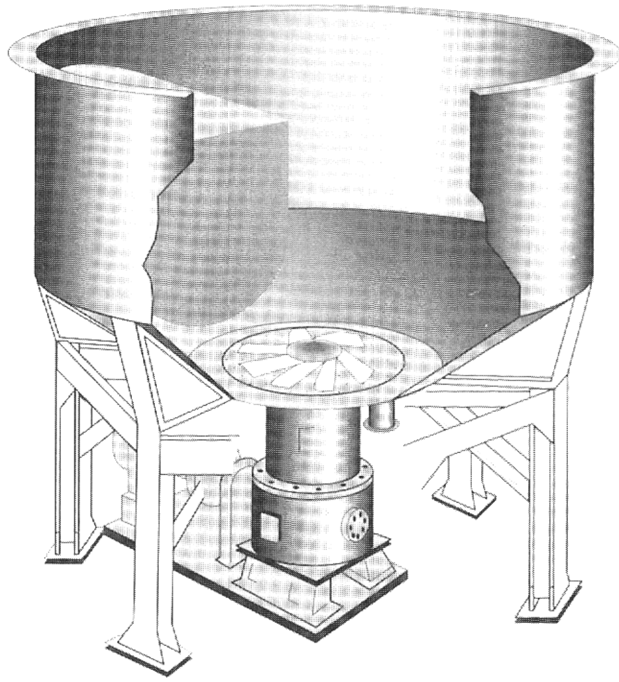

Fig 6 The Black Clawson D-chord baffle

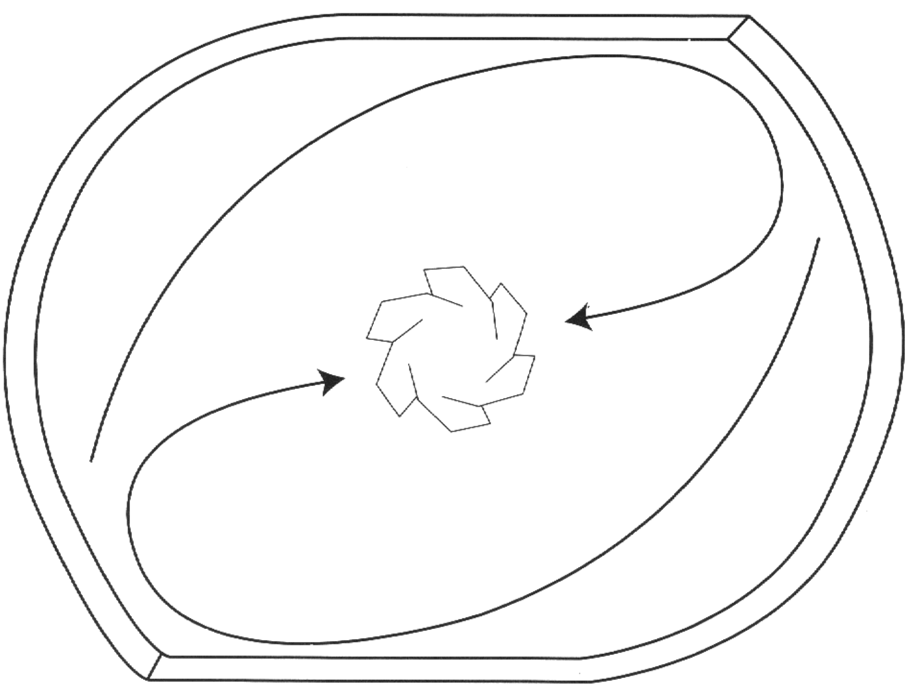

Fig 7 Beloit Sigma tub

A different approach is that of Beloit, who have devised the 'Double Contour' or 'Sigma' tub shape to achieve a better disintegration pattern, as shown in Fig 7. There are no examples of this in the UK, but Beloit claim that at lower consistencies on OCC defibring time is cut in half, with a proportional saving in energy demand. The Tridyne pulper in the Double Sigma vat, can operate batchwise at up to 12% consistency and with less breakdown of contaminants.

Other manufacturers have devised their own way to reduce the wasteful effect of laminar rotation flow, apart from the vanes and baffles already mentioned, usually by varying the height to diameter ratio. For new pulpers, the benefit of these different developments will be reflected in the energy use figures quoted, as discussed in the following section.

2.4 Range of Energy Use

As part of the preparation of this Guide, ten major manufacturers of pulpers supplying the UK were requested to provide information detailing their requirements to meet a variety of particular duties. The treatment of four different furnishes were selected for comparison:

- virgin pulp;
- broke;
- OCC;
- recycled newsprint and pamphlets.

In each case requests were made for requirements to deal with output rates of 50, 120 and 300 tonnes/day. Responses were received from the seven manufacturers listed in Appendix A.

Information was sought for each duty on:

- the recommended consistency of pulping;
- the tub volume;
- installed HP;
- average kWh/te power consumption of the pulper alone (that is, excluding the dump pump and any ancillary equipment associated with the pulper).

Table 1 shows the results for virgin pulp which was stated to comprise bales of bleached kraft, 75% hardwood, 25% softwood, unheated in a batch operation.

Table 1 Virgin Pulp: range of response from different manufacturers

Output te/day	**Consistency %**		**Volume m^3**		**Installed motor HP**		**Energy use kWh/te**	
	High	Low	High	Low	High	Low	High	Low
50	10	5	15	6	200	56	47	15
120	10	5	30	11	400	98	31	14
300	10	5	80	24	600	112	24	10

It should be noted that the models adopting high consistency did not necessarily have the smaller tub size nor a low installed motor HP.

The large range of the responses is very noticeable. In particular it will be seen that the specific energy consumption varies over a range of 3:1, a very considerable difference. One reason for this, of course, is that manufacturers have a standard range of pulper sizes, and the particular tonnages chosen for comparative purposes may fit better into the range of one supplier than another. The extraordinarily wide range of tub size (4:1) and installed HP (5:1) quoted will obviously be reflected in the capital costs for installation.

This points to the necessity, when purchasing a new pulper, of reviewing not simply the capital cost, but the running cost as well. The high cost of running pulpers can mean that capital saved on the installation may quickly be lost in extra power costs. With this type of equipment it is essential to calculate the operating costs over a two or three year period, and compare the total cost over this length of time in order to determine the best choice from a financial viewpoint.

2.5 Development of More Efficient Pulping

The basic shape of pulpers on the outside belies the development that has taken place over the years as a better understanding has evolved of the fundamental mechanism taking place. There is still no theory of pulping which would describe the effect of different parameters on the energy consumption, and all manufacturers use tables for sizing pulpers which have been empirically derived, although often the figures are backed by pilot plant or full size unit tests.

Many manufacturers will insist on testing the client's own stock, especially where the material is non-standard. Experience has shown that the degree of pulping required to defibre to the desired degree may vary considerably with the source and condition of the furnish. A good example of this is the considerable difference between linerboard emanating as waste from North America, where it is still largely made from virgin fibre, and UK-produced liner which is virtually all recycled.

Nonetheless there has been considerable change in the shape of rotors over the years, especially the development of the medium and high consistency designs, and much work has been done to define the optimum position of vanes and baffles to promote better circulation in a complete sense. Increased contamination has had its own effect on design, largely to produce more effective removal of heavy and light non-fibrous material. This requirement in turn has introduced a wide range of ancillary devices (see Section 5.1).

Development is still continuing, and off-the-record comments indicate that new designs of OCC and under-the-machine (UTM) pulpers are in the pipeline. Their efficiency with respect to energy usage will be a prime factor in their success.

One aspect that is better appreciated is that for optimum energy efficiency the degree of defibring carried out in the pulper, as opposed to later defibring devices, needs to be carefully assessed. Because of its high energy use it is not economic for the pulper to be used to reduce fibre bundles to a completely defibred state. Deflakers and, for finer fibrillation and cutting, refiners are both more effective in this task. Sunds Defibrator have developed a method of determining the relative energy that should be put into each piece of equipment in order to develop the required degree of disintegration efficiently.

The Sunds Defibrator method is to take stock after different degrees of treatment and measure what they term the Stock Quality Degree (SQD). This effectively compares the development of tensile strength as being the simplest measure of fibre change. To determine the SQD a sample of the disintegrated pulp is added to a standard laboratory sheet-making machine, at sufficient dilution to produce a 60 gsm handsheet, with mixing being done only by hand to allow a satisfactory sheet to be formed. Tensile tests on the resulting replicate handsheets are compared to those obtained on fully disintegrated stock from the same sample, following in this case the standard SCAN procedure for sheet making. To determine the fully disintegrated value the sample is treated until there are no fibre bundles present, a step which in the case of broke and flash-dried pulp introduces a subjective aspect that is overcome by continuing disintegration until the tensile strength increases by less than 5% after a further 10,000 revolutions of the disintegrator.

Fig 8 illustrates the principle by which the SQD test is then used. Note that the 100% SQD figure relates to a fully defibred pulp which then passes to a refiner for fibrillation to develop strength, etc. Pulping and refining is sufficient for ordinary sheet dried pulp, but for flash dried pulp (as illustrated) deflaking is added to minimise energy use. This would equally apply to machine dry broke.

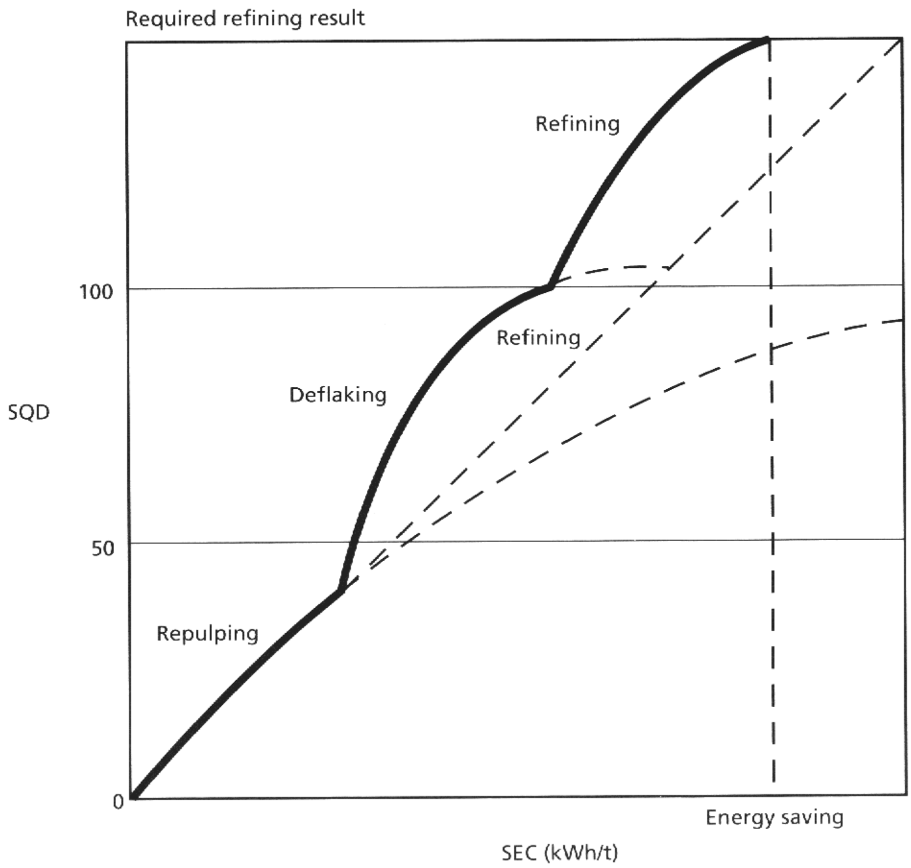

Fig 8 The use of 'Stock Quality Degree' to optimise energy use between different equipment (provided by Sunds Defibrator)

A similar approach is that of continuous pulping with a larger hole size in the bedplate. The pulper dumps through a thick stock screen with the reject passed through a deflaker back to the pulper. Overall this is claimed to use less energy and is particularly applicable to OCC.

A radically different approach is known as 'explosion pulping'. This system, devised by Stake Tech in the USA, is more akin to the digesting of pulp and is claimed to be particularly applicable to waste recovery. The waste is shredded dry by hammer mills, heavy contaminants are removed and it is then soaked with 50% water for several minutes. This is then fed into a screw feeder conveyor, which compresses the stock into a plug and forces it into a high pressure steam digester (200 to 400 psig). A helical rotating screw moves the material to the rear where the stock is released every 5 to 15 seconds through an automatic discharge valve, open only for 0.5 to 1.5 seconds (the explosion) and blows into a bin. The process has similarities to dispersion, and like that process effectively disperses hot melts and stickies. As yet no commercial application is known and the potential effect on energy use is difficult to assess.

3. VIRGIN PULP

Different considerations govern the use of pulpers for different furnishes. For the purposes of discussion, this Guide covers five types of application with very different requirements:

- virgin pulp;
- broke;
- OCC;
- news and pams;
- UTM pulping.

Furnishes are often mixed, broke with virgin pulp, mixed waste with OCC, etc, but the five uses cover all major types of application.

3.1 Batch Pulping

It is usual to treat virgin pulp in a batch process, particularly machines which frequently change the furnish to suit the product being made. Each batch will be selected according to the product, and reliance is placed on subsequent holding chests to remove any batch to batch variation and to provide as clean a separation between makings as possible.

Black Clawson recommend continuous operation in their D-chord pulper when this is suitable. They claim that retro-fitting a batch pulper to make it into a D-chord operation, and running continuously, can have a one year energy saving payback. However, a deflaker must be added to treat the dumped stock, and if the running cost of this is taken into account, the payback extends to two years. Voith-Sulzer also advocate continuous pulping of virgin pulp and claim to have many successful installations in European fine paper mills.

For a new installation, a further consideration is that the installed cost of batch pulping will generally be higher due to the need for a larger pulper, a larger dump pump and downstream chests. On the other hand, batch pulping is thought to provide a more controllable environment for uniform pulping, and is especially appropriate for fine paper machines making a variety of products demanding different combinations of pulps.

The process of operating by batch offers several ways to save energy. The usual sequence, with example durations, is:

Fill the tub	2 minutes
Add bales of pulp	1 minute
Disintegrate	4 minutes
Dump	3 minutes

Each operation will be controlled on a time basis. Within this simple sequence, however, lie a number of options.

Consider first the matching of output from the pulper to that of the machine. While the pulper may need to be run almost all the time when the machine is first laid down, changes over the years in demand from the machine, the installation of further pulpers for different types of furnish, and the controlled addition of broke perhaps augmented by bought-in clean waste, may serve to alter drastically the relationship between pulper and machine output.

Case History 1: East Lancashire Paper Mill

At East Lancashire Paper Mill, batch time for the furnish feeding PM5 was around 10 minutes for 1 tonne batches. This represented only 28% of the available time. The sequence installed stopped at the point where the tub had been emptied, although in practice sufficient stock was left to cover the rotor to reduce splashing, because of the difficulty of completely emptying the tub. The cycle then paused until a signal was received from the dump chest to indicate that there was now sufficient space to receive another batch, actuating the continuation of the cycle.

The operation of the pulper was monitored over a week-long period by attaching a data logger to measure the power consumed. On average, the power consumed was 110 kW during the part of the cycle when pulping was taking place. During the remaining time it was 55 kW. Apart from steadily declining when the pulper was emptying, the 55 kW level effectively applied the whole time the pulper was not actually full of pulp, including when it was waiting for a signal to restart.

The pulper was already equipped with a soft start, on average only used once every half hour, so it was decided to modify the sequence programme to switch off the pulper during the waiting time. This cost less than £2,000. **THIS ACTION SAVED THE MILL OVER £10,000 IN ENERGY COSTS, WITH A PAYBACK OF JUST OVER TWO MONTHS.**

A similar situation applied to a second pulper, but in this case the pulping power demand was much higher, there was no soft start and the motor could not be fitted with one. A disused sister pulper, which could be fitted with an existing soft start and motor, was brought into line. This necessitated spending a considerable sum in renovation and fitting of a new power supply and dump pump, but nevertheless even in this case the payback was less than two years.

Where demand on the pulper is relatively low, and especially if the pulper is not equipped with a soft start, an alternative approach is to ensure that the pulper is emptied completely. Power taken between cycles will then be lower than if some pulp is left covering the rotor. The rotor would be stopped well before the pulper is emptied, and started only after commencing water addition. However, this necessitates running the dump pump for longer, a power use that offsets the benefit of the lower power used when the pulper is empty.

A better but more costly solution is to fit a variable speed motor, allowing the rotor to be slowed to an idling speed when the pulper is being emptied until refilling commences. Variable speed facilities are considered in Section 8.

Where the pulper has to be run all the time for the batches to keep up with the machine, there are other options which can reduce the specific energy consumption. For example, it is acceptable practice to start adding pulp when the tub is only partially full, say 40%, of water, provided the rotor is sufficiently covered to prevent the possibility of damage from a bale falling directly onto it. This reduces the cycle time and either allows greater throughput, or lets the pulper run for longer at low load when empty.

Another possibility which may be applicable is simply to run the pulper at a higher consistency. Apart from the effect of consistency itself (see Section 2) increased consistency will also allow greater throughput or longer idling time, both of which reduce specific energy consumption. If the pulper is being fed with a mixed furnish, however, it may be less convenient to deal with a different number of bales per batch. For example, in the situation mentioned in Case History 1 the consistency could readily have been raised, but only by altering the furnish from one bale softwood to four bales of hardwood to one to five, which would have had an unacceptable effect on quality.

3.2 Medium Consistency Pulping

Pulping of virgin pulp at medium consistency can have power usage advantages. Most manufacturers have developed special 'low energy' rotors for batch pulping at higher

consistencies, many of which can be retro-fitted to a conventional design. Some manufacturers claim that this has a payback of under two years, but examination of the possibility as an alternative in Case History 1 was not so attractive.

In Case History 1 installation of a new medium-consistency rotor allowing pulping at 6% to 7% consistency, together with the fitting of a new pump to deal with the higher consistency of stock on dumping, had a payback of five years. This excluded the provision of flushing water, and its associated control, to dilute in the pump suction at the start of dumping. An alternative option of building up the sides of the pulper tub to allow pre-dilution was impracticable without modifying the conveyor. Both courses of action would have added appreciable additional costs making the project even less viable.

However, such a change can be beneficial when a significant increase in throughput is required. In this case, using a medium consistency rotor rather than an additional pulper can provide a much more attractive payback, by removing a bottleneck and in reduced specific energy consumption.

Case History 2: Tait Paper

In a new installation, the benefits from an energy standpoint in running at medium consistency are well worth considering. Under the Energy Efficiency Demonstration Scheme, an assessment was made of the Beloit Tridyne pulper design operating at 11.5% consistency. This was installed in 1986 as part of a new machine project at Thomas (now Federal) Tait, to pulp hardwood and softwood bales feeding the Printings and Writings machine at a rate in excess of 10 te/h.

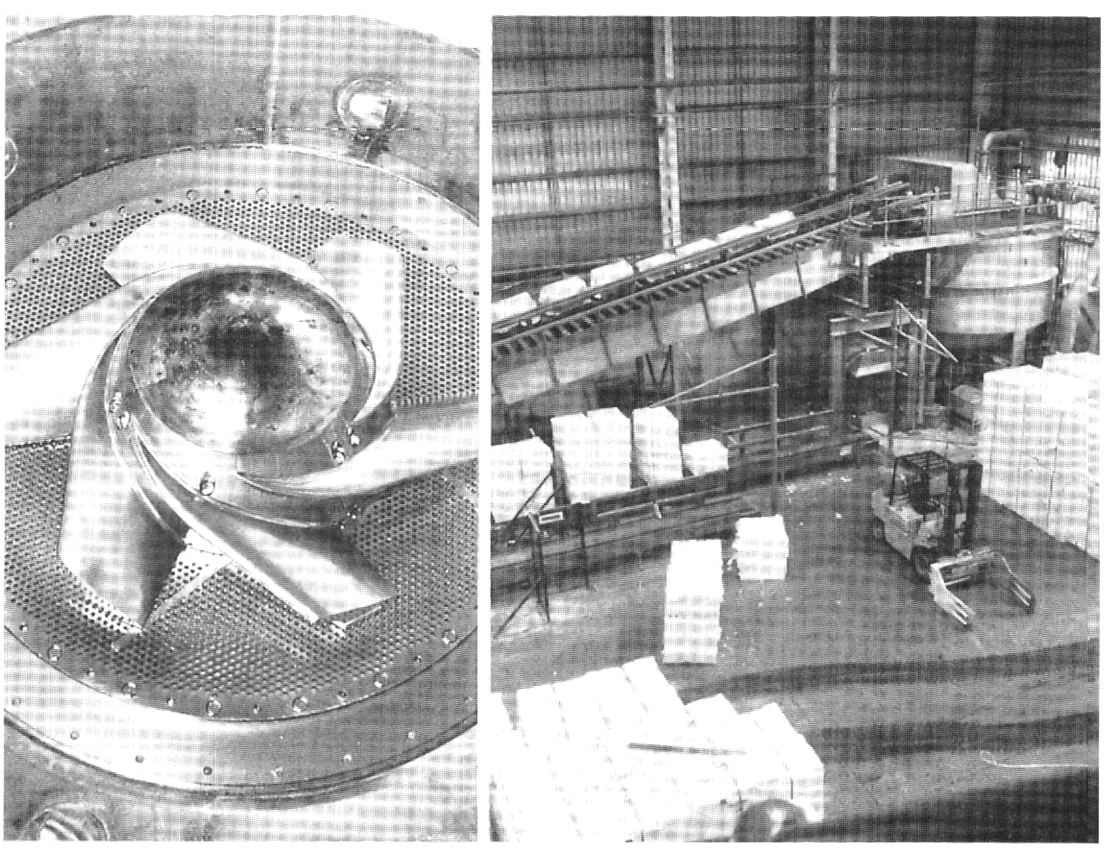

Fig 9 Tridyne rotor, and pulper installation at Tait Paper

The energy consumption in the batch operation was averaged over many cycles at 21 kWh/te including dump pump power usage, or 19 kWh/te excluding this. Occasionally the hardwood and softwood were pulped separately and the softwood was then pulped on a manual as opposed to the usual automatic cycle when power consumed rose to 24 kWh/te. Comparison was made with another smaller (3 te/h) pulper at the mill feeding a second machine and operating at between 6.3% and 7.0% consistency. In this case the average power consumed averaged 79 kWh/te, which is well over the then industry standard of around 60 kWh/te.

Taking the lower industry standard figure, the annual energy savings alone represented almost half of the installed cost of the pulper. If assessed labour savings stemming from the use of a single large pulper were added, the payback to cover the cost came to just under one year. Even this figure is pessimistic, because the alternative of installing two lower consistency pulpers would have been much more expensive, even without the additional ancillary equipment and building space required.

The disadvantage of a single pulper is the increased risk factor of failure, although in the two and a half years monitored there was only one incident of production loss. By the end of the period the pulper was being run at an additional 20% capacity.

It is instructive to compare the average energy consumption quoted in Case History 2 with the figures provided in Table 1 by different manufacturers. The monitored values are towards the top of the range, and some of the lower values are in fact for pulpers running at low consistency. This highlights both the desirability of making a close comparison of different models of pulper and the advances in pulper design which are taking place.

4. DRY BROKE

In fine paper mills which make a variety of products, segregation and controlled addition of broke from a separate pulper, often augmented with bought-in good quality waste, are usually a feature of the operation. Separate broke pulpers are also used in the manufacture of other products, although they have tended to be superseded by pulpers under the dry end of the machine which operate in a different way (see Section 7). The basic broke pulper is commonly run in a batchwise system, in a similar operation to virgin pulp, to allow the furnish composition to be appropriate to the product being made at that time on the machine. The pulper is fed with:

- all dry broke in slab form torn from jumbo and slit reels;
- sheet broke from the finishing department, which may have been baled;
- reject rolls from the slitter, coater and other reel fed finishing operations.

Trim from slitters will be blown directly to the pulper or to a baling device. A reel splitter is preferable for dealing with reject rolls rather than knocking out the core and loading directly into the pulper.

Loose broke is easier to disintegrate than broke in other forms, which is of much higher density. To combat the problem of the broke floating on the surface, however, it must be added with the pulper almost empty. The tub is then part filled with water before the rotor is started and the remainder of the water added. Control of consistency can also be a problem if, as is common, there is no facility to weigh the batch feed. Reliance is usually placed on the experience of the operator to add sufficient broke to a point where he judges the consistency to be suitable. This task is aided by the fact that with insufficient material a funnel will be formed in the centre which sucks in air and adversely affects the whole process of disintegration. Trim blown directly into the pulper will often float on the surface, but not normally in sufficient quantity to affect the operation.

Dry broke is more difficult to disintegrate than virgin pulp of the same fibre, because the moisture content is lower and bonding strength has been developed in manufacturing the paper. If the paper has been wet-strengthened, then the broke is very hard to pulp and requires special chemical treatment. It is not surprising that to meet similar requirements in output terms, the same manufacturers that were approached for data relating to virgin pulp quoted higher energy demand for pulping broke. The relevant figures are shown in Table 2. They relate to dry broke with starch, fillers, etc., batch-pulped unheated off-machine in a vertical operation with the broke fed in a form which could include roll offcuts.

Table 2 Dry Broke: range of response from different manufacturers

Output te/day	Consistency %		Volume m^3		Installed motor HP		Energy use kWh/te	
	High	Low	High	Low	High	Low	High	Low
50	10	5	20	7	200	82	48	15
120	10	5	46	18	500	149	48	15
300	10	5	95	35	1,000	250	39	14

Once again the extremely wide range of responses should be noted.

The same general comments discussed for virgin pulp apply to broke pulping, and again there are situations where running at higher consistencies may be advantageous.

Case History 3: Henry Cooke Makin at Oakenholt

The Mid-Con rotor from Black Clawson is a typical medium consistency rotor. It is suitable for retro-fitting to low consistency rotors from the same company. This can be a beneficial modification to make where increased output is required, and it also reduces specific energy consumption.

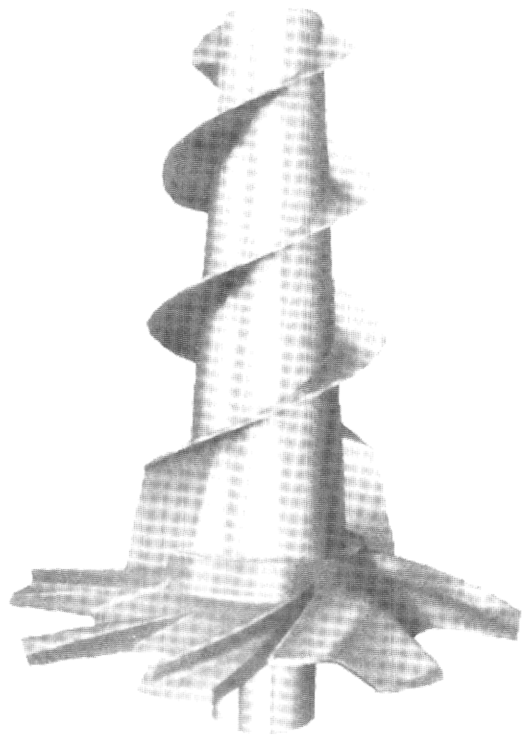

Fig 10 Mid-Con rotor

Henry Cooke Makin at Oakenholt attached Mid-Con rotors to two 10-foot Black Clawson pulpers already equipped with Vokes rotors and the Powr-Savr modification. This was to slush an average 20% pulp, 80% clean waste (trimmings, computer stationery, etc.) similar to normal mill broke. Consistency of operation was increased from around 4% to 10%, and tonnage from 2.4 te/h to 4 te/h (for both pulpers).

The power consumed remained the same at 220 kW total, so specific energy consumption dropped from 92 to 55 kW/te. Payback at the time was estimated at seven months.

Due to the need for increased future capacity, as part of a major re-build of the stock preparation equipment in a new building, these two pulpers were subsequently replaced by a single new 14 foot Mid-Con pulper, including new switchgear. Payback purely in energy terms was four years, mainly because at the time little advantage was taken of the increased potential capacity.

The mill observed that shut time with the Mid-Con rotor was much less than before, because stoppages to release a jam underneath the rotor or to clean out accumulated rubbish are rarely required. This is attributed to the lifting action of the screw, which also reduces load on the bearings, thereby reducing maintenance downtime.

5. OLD CORRUGATED CONTAINERS

Old corrugated containers (OCC) and other mixed waste used for brown products inevitably contain a variety of contaminants, which may account for up to 5% by weight of the feed.

All OCC pulping operations have to cope with heavy contamination, in the form of everything from nuts and bolts to bale wire, and with lighter contaminants such as plastic sheet and pellets, adhesives and other sticky material.

Because it is necessary to remove the contaminants, but at the same time avoid breaking them down, the material is always pulped continuously at low consistency, and the rotation speed of the rotor is relatively slow.

The main development in OCC pulpers has been in the design of different contaminant reject systems within the tub and ancillary means of removal outside the pulper itself. The aim is to keep the pulper sweet, and prevent the need to shut it down frequently to clean it out. Reduced energy usage has not been such an important motivating factor, although the development of new rotors and tub shape has had an effect on this.

5.1 Removal of Contaminants

Some typical design changes that have appeared are:

- raising the rotor and bedplate above the bottom of the tub;
- introducing a channel round the periphery, which catches large heavy contaminants before they can cause damage. This channel leads to a heavy junk chute which is automatically purged at intervals by a simple double valve arrangement. The junk itself can go to a tipping conveyor or straight into a skip, while the elutriation water used to wash out the pipe section between valves is fed to a separate screen to recover fibre;
- including a separate chamber at the side of the pulper, from which heavy material can be periodically lifted out by a crab shell hoist or grab.

A *ragger* (Fig 11) is the normal method of removing bale wires, strings and some plastic sheet by entanglement and will run in the outer channel. The ragger often uses a cutter where rope disposal is a problem. Some automatic bale de-wiring systems have been developed that remove the need for a cutter. The bales are fed in with wires uncut, and special vanes on the rotor are designed to perform the cutting action and create strong turbulence at relatively slow rotation speed. Systems have also been developed that remove the need for both ragger and cutter.

There is usually a purge from the side of the pulper especially to remove light material, and this will be fed to an enclosed screen with a rotor arrangement which may be an integral part of the pulper. As much as 40% of the pulper flow may be taken. This combined disintegrator and screen may be run on an intermittent basis, with automatic dumping of the junk at regular intervals or when pressure drop across the screen reaches a predetermined level. The elutriation water is purged by gravity or compressed air.

Alternatively, the screen may be run continuously with periodic stopping of the forward feed to purge the reject to another screening device. This is often of a rotating perforated drum design, with the accept returned to the pulper together with cleaning spray water, and the reject carried along the drum by a helix to a disposal skip. The hole size in the primary screens may be the same or smaller than those in the pulper bedplate, dependent on whether the intention is to feed forward directly or to recirculate.

A separate facility may be provided to remove large sheets of plastic without reducing their size making them less likely to pass down stream.

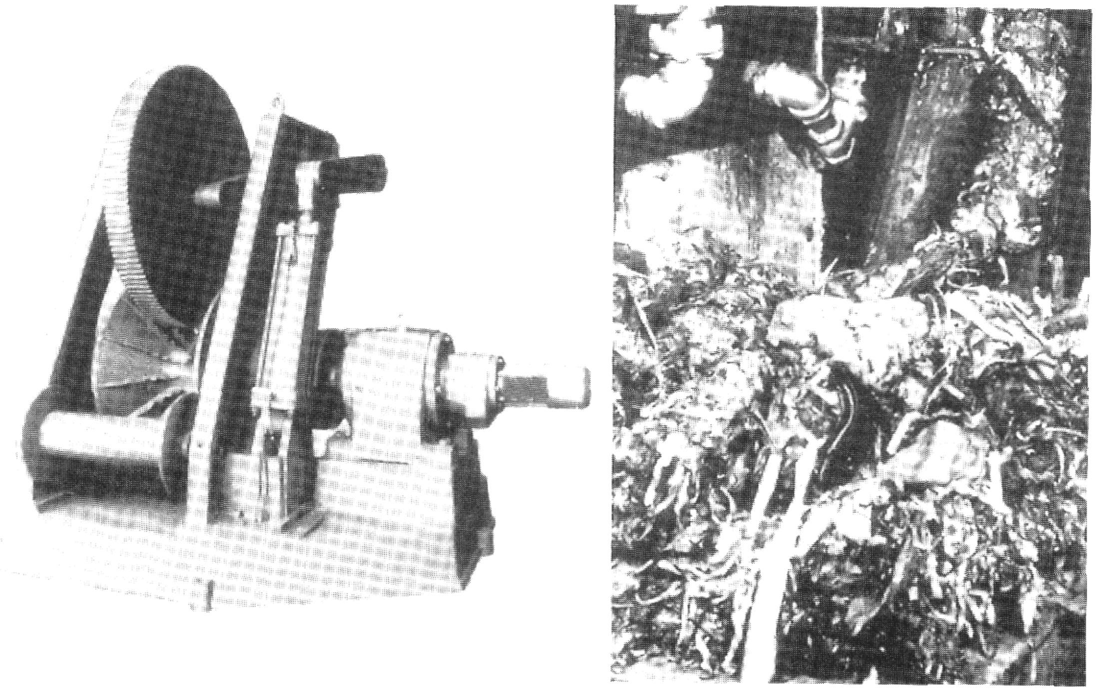

Fig 11 A ragger and ragger rope

For large installations (over 700 te/day), a technique that has found favour is to pre-soak the waste at high consistency, perhaps aided by caustic, in a slowly rotating drum with a special deflaking region. This reduces pulping time considerably, allowing a smaller pulper to be used, but the equipment is very expensive and demanding of space. Energy savings of up to 20% have been claimed for this technique, however, especially if bales are first crushed and disintegrated.

A system known as San-Ei is a variant of this, giving stock a prolonged alkaline soak in a high-density tower. It is claimed to lower pulper power demand significantly, by reducing the action to a rough pulping and with early extraction through plates that have a large hole size.

The merits of the variety of designs and ancillary equipment dealing with contaminant removal are beyond the scope of this Guide. Clearly the main criterion for selecting a particular piece of equipment will be how effectively it removes contaminant from raw material. Energy consumption should also, however, become significant factor in reaching a decision.

5.2 Energy Considerations

Because of the various ancillary devices associated with the pulping of OCC and similar waste grades, a direct comparison between the energy consumed by different designs is unreliable. Extraction plate hole size varies significantly, dependent on the satellite cleaning loops attached to the pulper and the downstream combined secondary slushing and coarse screening devices. The accept stock from these satellite systems may be sent forward or recycled to the pulper tub, and in some cases there is the facility to do either. In these situations it is not practicable to consider the pulper energy consumption in isolation.

To reduce the variables as much as possible, each manufacturer co-operating in the comparison exercise was asked to provide information relating specifically to the pulping of OCC and mixed waste in a continuous operation, using a pulper with 10 mm bedplate holes. Stock was specified as being heated to 60°C. The results are detailed in Table 3.

Table 3 OCC & Mixed Waste: range of response from different manufacturers

Output te/day	Consistency %		Volume m^3		Installed motor HP		Energy use kWh/te	
	High	Low	High	Low	High	Low	High	Low
50	5	4	15	6	100	67	29	16
120	5	4	30	17	250	110	29	14
300	5	4	60	28	600	250	29	13

The response range is less wide than for other types of pulping, but is still significant in terms of both energy use and likely capital cost.

The Black Clawson D-chord baffle is claimed to be of particular benefit when pulping OCC and mixed waste, because of its importance in ensuring good circulation in the pulper vat, separating the contaminants out without breaking them down, and because of its value in reducing energy consumption.

Case History 4: Trinity Paper

At Trinity Paper Mills, two Black Clawson pulpers (with raggers and ancillary contaminant removal), operating at 3 to 5% consistency on a furnish mainly of old corrugated containers, were modified at different times by adding a D-chord baffle. In both cases throughput increased by some 10% for the same power consumption, hence specific energy consumption in terms of kWh/te dropped by the same percentage. The mill calculated the payback in energy terms for the first modification as just under twelve months, but this was partly due to being able to stop using another pulper to augment the supply of heavily contaminated waste. For the subsequent modification the main purpose was simply to achieve a higher throughput and, although the same 10% increase occurred, the straightforward payback in this case was 19 months.

The original D-chord plate was 12 mm thick, and without protection of the tiles, holes were being punched through the plate by larger metal contraries. This problem was overcome by stitch welding a replaceable 30 mm plate to the bottom half of the 12 mm D-chord plate.

Control of consistency and flow forward in this type of continuous operation is very important if the pulper is to work efficiently. The following methods of control can be used:

- maintain the level of stock in the tub, to compensate for the rate of dumping, by installing a sensor at the side of the tub to control the addition of water;

- controlling consistency of the stock by dump pump flow measurement, which then edges the conveyor forward by an amount governed by pre-set average load conditions;

- consistency may also be controlled from motor load on the rotor, but shock load from individual bales complicates this method;

- the pulper level can be controlled by bale addition, and consistency by rate of dilution. this system is claimed by some to be preferable.

The beneficial effect that increasing temperature has on specific energy consumption has already been mentioned, and this applies equally to pulping OCC. Beloit have illustrated, however, that increased temperature also has a deleterious effect on contaminants, particularly on waxes, stickies and plastics associated with OCC (also magazine bindings used in newsprint manufacture). Fig 12 shows that contaminant size decreases with increased temperature, and Beloit suggest that a compromise between this effect and that of increased output is required in the 100°F to 120°F range.

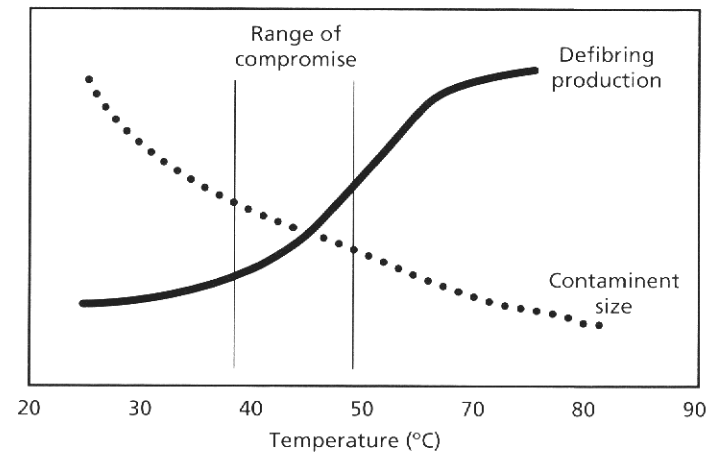

Fig 12 The effect of temperature on energy and contaminant size when pulping OCC (provided by Beloit)

The general tendency these days is to use single large pulpers which, although vulnerable to the risk of lost production if they break down, significantly reduce capital cost and energy consumption compared to two smaller pulpers. The latest OCC installation in Japan is a 27 foot pulper with a 1,600 HP motor producing over 1,000 tonnes per day.

6. NEWSPRINT AND PAMPHLETS

When pulping over-issue and used newspapers, pamphlets and magazines for subsequent newsprint manufacture, the most important requirement is the need to de-ink the material.

The initial part of the de-inking process takes place in the pulper where ink is loosened by heating the stock and adding chemicals. These chemicals include:

- caustic, to aid breakdown;
- bleaching agents, to minimise yellowing from caustic addition;
- chelating agents, to tie up precipitates in the water;
- chemicals, to free the ink;
- dispersants;
- soaps.

All these chemicals must be metered in at the appropriate time during each batch. The cost of the chemicals and the amount of heat required are both reduced if the pulping takes place at as high a consistency as possible. This requirement has lead to the development of pulpers which disintegrate the stock at consistencies of up to 18%.

These pulpers always operate by batch, and at high consistencies may have no perforated bedplate, relying on good screening after dilution through a separate unit downstream. This method reduces cycle time (and specific energy consumption) and is used to help prevent the likelihood of the pulper plugging during dumping. Where holes in a bedplate are used these will be of large diameter (18 to 25 mm), and after dumping there may be a flush-out to a reject unit through a separate large opening at the side of the pulper. Light rejects may be separated out and treated in a rotating drum or vibrating screen arrangement.

The pulper stock must always be diluted before it can be dumped. This may be done in a separate dump pipe at the side of the pulper, or water may be added into the pulper through a special channel at the side or under the rotor. The process should be carefully controlled, as the pulper may overflow if there is any blockage during dumping.

Table 4 shows the range of response of the pulper manufacturers to the specific requirement to de-ink newsprint and pamphlets batchwise with stock heated to 60°C.

Table 4 Newsprint & Pamphlets: range of response from different manufacturers

Output te/day	Consistency %		Volume m^3		Installed motor HP		Energy use kWh/te	
	High	Low	High	Low	High	Low	High	Low
50	16	7	10	5	250	75	71	20
120	17	8	25	10	500	110	54	18
300	17.5	7	65	30	1,000	250	48	16

Once again the range of the responses in respect to tub volume, installed HP and kWh/te used is remarkably high, and it should be noted that there was little correlation between power consumed and consistency. In fact both higher and lower values given for power consumed apply to high consistency operation, and operation at the low end of the consistency scale embraced both high and low power consumed figures.

Fig 13 shows the effect on brightness of the de-inked stock when pulped at different consistencies. These results from Beloit indicate that although the unit energy consumed reduces for higher consistency in a particular pulping operation, the brightness also decreases. Since stock brightness is an important attribute in any de-inking process, Beloit interprets this graph to imply that there is a recommended range of compromise in the 10% to 12% consistency region. Above this range energy savings are minimal when compared with the decrease in brightness. The graph relates to old newspapers, for recycled office waste the harder thermaset xerographic inks found in laser printers and office copiers affect the brightness less when they are broken into specks, and consistency may then be raised beneficially up to 16%.

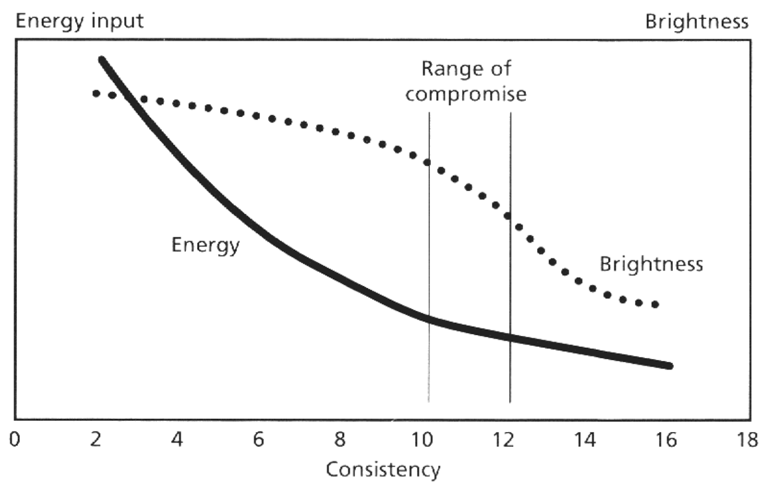

Fig 13 The effect of consistency on energy and brightness when pulping for newsprint (provided by Beloit)

The effect of temperature on contaminant size, illustrated in Section 5 and Fig 12, is also relevant.

For this particular furnish, the relationship between the different costs of energy, chemicals, heat required, and brightness, must all be taken into account when evaluating proposals from different manufacturers. Most manufacturers insist on testing samples of the material to be pulped, including the chemicals that will be used, so a complete comparison of all the costs involved is possible.

There is also a school of thought that continuous pulping, which is at low consistency, is better for de-inking. This is yet another illustration of the fact that energy consumption, though highly important to the economics of the recycling operation, can only be considered as one element in the process of producing from waste a satisfactory substitute for virgin pulp.

As the de-inking effect in a pulper may vary, and some inks may smear at high consistency and completely ruin a pulper batch, there are those who advocate an empirical approach. This demands close attention by the operator, to determine the degree of pulping and to make control decisions. If the load fails, the operator diverts the load to a bad batch chest from where it may be bled into the system or dumped altogether.

7. PULPERS UNDER THE MACHINE

Pulpers positioned under the machine (UTM pulpers) have separate demands on them, and their shape is governed by the need to be able to receive the maximum width of the sheet being made on the machine. Side mounted rotors are usual as headroom is often restricted.

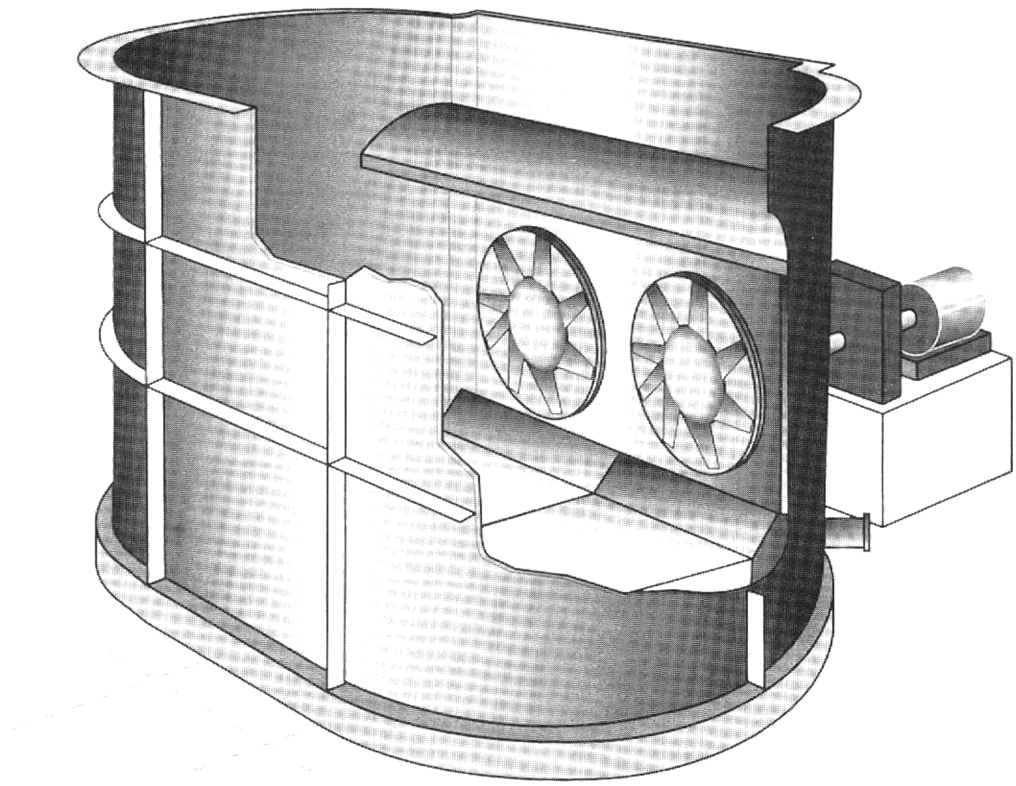

Fig 14 A typical UTM pulper

For all but tissue and other lightweight grades it is desirable to avoid telescoping of the web as it falls from the machine. For this reason a UTM pulper should ideally be slightly wider than the full width of web it is designed to receive. This is generally difficult to arrange within the concrete supports for the machine sole plates, except on completely new machines. As the rotor and bedplate need to be covered to prevent excessive splashing and air entrainment, this design requires that level in the pulper is maintained at 100 to 200 mm above the upper part of the rotor. This in turn dictates the manner in which the pulper is run.

UTM pulpers are used at all positions along the machine where a break in the web may occur (or where the sheet may be quickly broken in the event of breaking elsewhere), including positions beneath the following:

- couch;
- press section;
- size or coating station;
- reel-up and winder.

Where broke is difficult to handle, some machines are equipped with full width conveyors to transport paper or board underneath the drying section to a pulper. The pulper must be capable of receiving and breaking down the full machine production for an indefinite period. In the couch, and sometimes also the press position, a simple cross shaft agitator suspended across the machine in the middle of the tub can be sufficient to break down the wet web.

In the other positions, where the sheet is dry, a full rotor, perhaps augmented by an agitator, is required. On wide machines over five or six metres two rotors are needed to ensure adequate circulation. One of these will be switched off during normal running.

This variety of duties, and the operational restrictions, mean that UTM pulpers are often designed for a specific job. Comparison between manufacturers is therefore less meaningful than with the earlier examples. However, requests were made for the same set of data to be provided, for pulping at the reel-up the full output from a printing and writing machine. As machine width is such an important factor, this too was specified. Table 5 gives the results.

Table 5 UTM Pulper for reel-up broke on a Printings & Writings machine: range of response from different manufacturers

Output te/day	**Consistency %**		**Volume m^3**		**Installed motor HP**		**Energy use kWh/te**	
	High	Low	High	Low	High	Low	High	Low
50/3m wide	16	7	10	5	250	75	71	20
120/5m wide	17	8	25	10	500	110	54	18
300/8m wide	17.5	7	65	30	1,000	250	48	16

Once again the wide range of values for each parameter underlines the need to seek several options and compare the cost of capital and power together over a period.

A recent development in design of UTM pulpers from Valmet Tampella is claimed to reduce energy requirement by at least 35%. Instead of the traditional straight-sided type of tub, the cross machine surfaces have been rounded so that the tub bottom is semi-circular. These tubs are of fabricated construction, and can be installed by positioning the support legs on prepared foundations without the necessity to grout underneath for additional support. This design was used for PM3 at St Regis Kemsley.

Control of the consistency of a UTM pulper is crucial to successful operation. For most of the time only side trim, occasional slabs thrown in or winder trim may be entering the pulper, yet it must be ready to receive and deal with the full production at any time. Various solutions to this requirement are used, and depend on rapidly turning on a pre-set volume of dilution water and starting the dump pump. The dilution water is usually sprayed in across the full width of the pulper directed at the bottom of where the web falls to try and ensure that the web is forced into the pulper without air entrainment and to prevent it accumulating on the surface. If the pulper is virtually enclosed it may be necessary to extract air from the upper region.

During normal running a small pump may be used to remove the stock as it builds up and consistency may be controlled by a separate recirculation line. Alternatively, the level may be allowed to build up to a pre-set point when the dump pump is started as in a batch operation. If consistency can be kept high enough (often a problem), there is no need to pass the broke over a thickener before returning it for controlled addition to the machine feed. A deflaker is used for dry broke.

Each machine with a comprehensive set of UTM pulpers will have its own requirements and control systems. Since the pulpers have to be run all the time in a stand-by situation, careful consideration of how this is best done can minimise unnecessary use of power. One way is to pump from one pulper, which is not fully operating, to another which is kept going all the time. Use of variable speed rotors is an option that can be beneficial, using an idling speed during normal running.

8. DRIVES

Pulper drives are usually either:

(i) direct-on-line with a single gear reduction unit through a hypoid ring and pinion;

(ii) a hanging V-belt for light or medium duty, usually with the motor side-mounted for ease of maintenance.

There are still some designs with the motor suspended directly underneath. Starting the rotor pulls many times normal current, and exerts considerable strain on the motor and drive to provide the torque needed to overcome initial inertia. This is especially the case if the pulper is not empty. If the pulper is stopped full it may be impossible to start the rotor, and there is no option but to drain the water and dig out the pulp.

This has lead to the widespread adoption of soft start electronics which ramp the voltage at start up and avoid the sudden shock load. This represents such a small part of the total cost of a motor drive installation that all pulpers should be equipped with one, provided the motor is suitable.

An even better facility is a variable speed control which will incorporate the soft start. This allows various options to be introduced into the pulper control system to allow energy saving. For instance, in batch operation a 10% saving has been claimed by reducing the rotor speed during the whole period of emptying and re-filling, reverting to full speed only as new furnish starts to enter the pulper. Reduced dumping time is also claimed because the pulper empties more easily with less swirling, and two or three additional batches may be processed over a 24 hour period. Reducing rotation rate can also be beneficial in the emptying phase as less air will be sucked in to the dump pump.

In continuous operation speed can be reduced when full feed forward has to be interrupted. Similarly, with a UTM pulper there is the option to have the rotor running at slow speed until there is a break. When operating at full speed, the drive will be switched to direct-on-line to save power losses in the inverter.

Installing a variable speed drive as a retro-fit is not always attractive in payback terms, because the initial cost is high. Some mills have done this, however, to increase rotor speed in order to enhance throughput. One recorded example succeeded in reducing batch time from 120 minutes to 65 minutes with a wet-strengthened waste furnish, and from 30 minutes to 20 minutes on virgin pulp, by speeding up the rotor to a level where it drew 90% of full current load. The practice has now been discontinued due to unreliability of the inverter. Manufacturers will not usually be in favour of increasing rotor speed, pointing out that they design the rotor for operation at a maximum speed, and running faster brings with it the possibility of cavitation at the edge of the rotor blade, which is inefficient and can burn fibre.

A different approach affording the same soft start facility is the Voith hydrodynamic fluid coupling (Fig 15). This is designed to slip when operating at full load, and reduces peak electrical load, saving on power factor provision in the distribution system. It also serves to cushion the drive against vibration and shock loads. A delayed filling chamber is available to provide an even more gentle start; this is useful if protection is required against the possibility of having to start a full pulper. Sometimes both a variable speed motor and a fluid coupling may be installed, the latter taking over once the direct-on-line phase is reached.

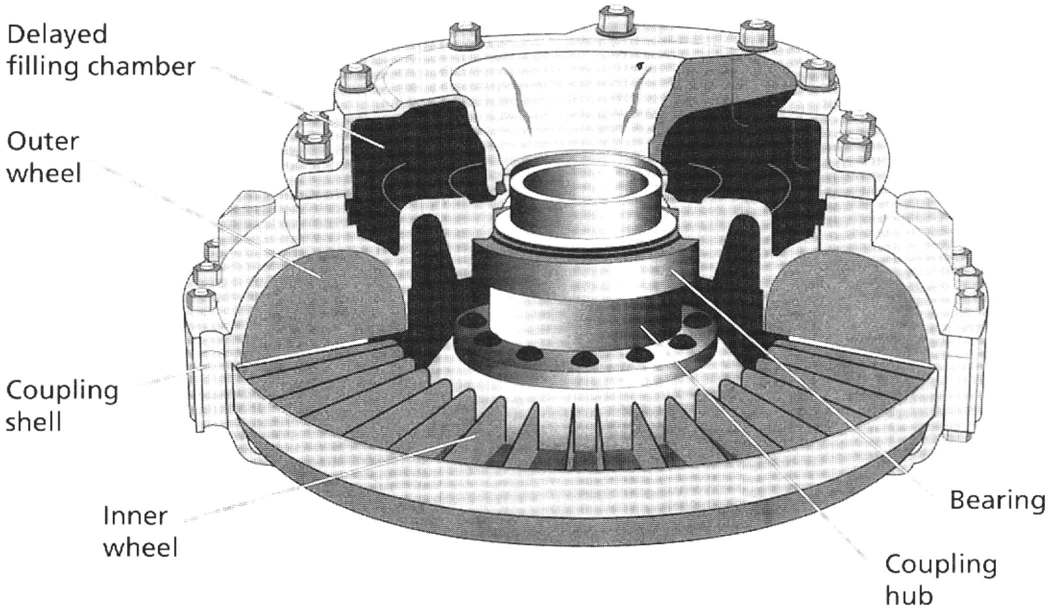

Fig 15 The Voith Hydrodynamic Coupling

9. MAINTENANCE CONSIDERATIONS

Apart from routine engineering maintenance following the manufacturer's guidelines, the main parts of a pulper requiring occasional attention are the rotor and bedplate. These both wear, and should be systematically inspected at intervals determined by how arduous the duty is. Damage and wear is obviously greater the more contaminated the furnish. Seals and packing boxes have to be checked, and with V-belt drives, constant showering with water and pulp creates problems.

A simple check list should be used during a formal weekly visual inspection to see if there are any signs of damage to baffles and vanes apart from the rotor itself. If the damage is serious it can affect the circulation and reduce efficiency. Every three to six months when pulping waste, and two to three years for virgin pulp, the leading edges of the rotor vanes need to be checked for profile and sharpness. The gap between rotor and bedplate also needs to be confirmed at different points round the circumference. Holes in the bedplate must be checked for sharpness, and the plate may have to be renewed or reversed where this is possible.

As parts wear in the pulper, energy consumption will usually increase for the same degree of disintegration of fibre. If energy consumption falls then either correct disintegration is not being achieved or there is a design fault in the pulper itself. For this reason the condition of the furnish, either at the point of being dumped or after a fixed pulping time, should be analysed periodically in handsheets by the laboratory. This analysis, together with regular power readings, will provide comprehensive information with which to check on gradual deterioration of performance.

Wear of the main drive, causing vibration, comes particularly from shocks to the rotor from bales falling onto it. This problem of bale shock can be alleviated by specially designed bale splitters on the edge of the pulper tub. Bale splitters can also help to break up bales more quickly, thereby decreasing consistency variation in the tub and reducing the risk of the pulper plugging.

Vibration monitoring is increasingly used in mills, which indicates immediately when damage has occurred, allowing early remedy. It is also helpful to have data logging equipment linked up permanently or occasionally to compare the power used in batch cycles. All these basic techniques will help to ensure that energy consumption is kept to a minimum.

If the maintenance described above is carried out, this should give assurance that energy is being conserved as much as possible for the customary operation of the unit. The apparent simplicity of pulping equipment makes it easy to assume that nothing further need be done. It is hoped that this Guide has shown the many ways in which an operation may be improved to reduce energy consumption and has also demonstrated that pulping development continues. A comprehensive maintenance and operational check list is shown on the next page.

10. MAINTENANCE & OPERATIONAL CHECK LIST

For routine pulper operation:

- check visually for damage to rotor, vanes and baffles every week;
- check at an appropriate interval for the profile and sharpness of rotor and bedplate holes;
- make handsheets of disintegrated stock for regular comparison;
- record, preferably on a data logger, how power consumption compares week by week;
- monitor vibration, which will help pick up early signs of damage.

For an assessment of whether improvement is possible:

- examine the batch process:
  - is the rotor stopped when not required?
  - if the rotor cannot be stopped, is the pulper kept empty when not required?
  - would a variable speed facility to slow the rotor when not pulping be useful?
  - would a small uplift in consistency reduce working time and allow the rotor to be stopped longer?
- would a new rotor be economical? Manufacturers are constantly improving design;
- check the power used against what other manufacturer's rotors need, power varies greatly from one to another and retro-fits are often possible;
- would a significant increase in running consistency be worthwhile? This can be costly with new pumping arrangements as well as a new rotor, but may be rewarding;
- can temperature be increased to at least 40°C?
- is the pulper being used more than is necessary? Deflaking and refining are more energy efficient for reducing fibre bundles and for fibre development;
- are UTM pulpers designed to use minimum power when the machine is running normally?

APPENDIX A

PULPER MANUFACTURERS ASSISTING WITH THIS GUIDE

Beloit Walmsley Ltd
Crompton Way
Bolton
Lancashire BL1 8UU

Black Clawson International Limited
Westgate Works
East Dock Road
Newport
Gwent NP1 2TT

Cellwood Grubbens AB
Parsons-Skilforce Engineering
Eton Hill Road
Radcliffe
Manchester M26 9XT

Valmet
c/o Pulp & Paper Machinery Ltd
85/86 Bank Street
Maidstone
Kent ME14 1SD

Sulzer Papertec
Falcon House
71-73 College Road
Maidstone
Kent ME15 6RW

Sunds Defibrator Ltd
10 Western Road
Borough Green
Kent TN15 8AG

Voith Engineering Limited
6 Beddington Farm Road
Croydon
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Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R & D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.